TAPE-SLIDE LECTURE PACKAGES FOR USE IN AERO LABORATORIES

Fred Palka

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

TAPE-SLIDE LECTURE PACKAGES
FOR USE IN AERO LABORATORIES

by

Fred Palka

Thesis Advisor: R. D. Zucker

March 1973

Approved for public release; distribution unlimited.

Tape-Slide Lecture Packages

for Use in Aero Laboratories

by

Fred Palka
Major, United States Marine Corps
B.S., United States Naval Academy, 1962

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
March 1973

ABSTRACT

Overcrowded conditions, unavoidable absence, and course priority in aero laboratories led to a quest for an instructional method which would alleviate these problems without increasing the instructional workload. The tape-slide lecture apparatus was selected as the vehicle for conveying the necessary information. Detailed scripts were written, slides were prepared and fully automatic and synchronized audio-visual packages were assembled. The results are four individual packages: The Low-Speed Wind Tunnel--Introduction, The Aerolab Low-Speed Wind Tunnel--Description, The Aerolab Low-Speed Wind Tunnel--Operation, and Technical Report Writing. Reaction to the results was favorable. It was concluded that the method was effective and recommended that work in this field continue.

TABLE OF CONTENTS

ACKNOWLEDGEMENT

I wish to acknowledge the help that I have received in preparation of the lecture packages and this report.

I am particularly indebted to Professor R. D. Zucker, who offered many valuable suggestions for improvement, and Professor D. M. Layton, who so graciously consented to be the narrator.

I also wish to give credit to the Photographic Division of the U.S.S. *Enterprise* and the Educational Media Department of the Naval Postgraduate School for their fine assistance in preparing the slides.

I. NATURE OF THE PROBLEM

A. OVERCROWDED CONDITIONS

When the equipment which is required for a laboratory experiment is small and transportable it is an easy matter to provide several sets of equipment and isolate one or two students on each set. Each student then gains maximum exposure to the equipment and maximum benefit from the experiment. This is usually not the case, however, in low-speed wind tunnel experimentation. The tunnels are very large and non-transportable and the test area can only adequately accommodate a limited number of students. In addition, the experiments are usually of such duration that to run them several times for small groups, each under the tutelage of an instructor, would not be feasible due to instructor availability. Thus even small classes can over-crowd the low-speed wind tunnel facilities.

B. ABSENCE

It is not altogether uncommon for a student or an instructor to be physically absent from a scheduled class because of illness or other unforeseen circumstances. If a student is absent, he must be afforded special tutoring in order to gain exposure to the material he missed. This places an added burden on the instructor. If the number of student absentees is large, the burden may become prohibitive with the result that some of the material is not

presented to some of the students. The situation is perhaps even more critical when an instructor is absent. Scheduling conflicts may prevent the class from being held at all with the result that some of the material is not presented to all of the students.

It is also quite possible to be physically present at a class, but be mentally absent. This type of absence is very insidious in nature and may be caused by illness or preoccupation with problems external to the class. The results of a mental absence are much the same as those of a physical absence. The absentee is not exposed to some of the material. Moreover, there may be a reluctance on the part of a student to admit to this type of absence and request special tutoring.

C. COURSE PRIORITY

In assigning the instructional workload, it is often necessary to give priority to critical lecture courses. The efficient use of faculty manpower might then dictate assignment of an instructor to a basic laboratory course which is not in his primary specialty area. This can act to the detriment of the quality of instruction.

D. STANDARDIZATION

There are numerous academic courses in which the desired learning outcomes for the student seldom change. In addition, the nature of some of these courses is such that the individual

lesson plans may remain quite current for long periods of time with little or no alteration. Basic laboratory courses generally fall into this category and, if effective lecture packages were created for them, the lecture packages would certainly endure through many quarters with only minor up-dating. This would appear to be an appropriate method of ensuring that the desired learning outcomes for the student are achieved and it has the added advantage of removing some of the burden from the instructor while at the same time allowing him a certain amount of flexibility.

II. PROPOSED SOLUTION

A. REQUIREMENTS

The nature of the problem seemed to indicate that it could be alleviated by some type of lecture package. The next step taken was to define the requirements such a lecture package would have to meet in order to be an effective solution.

1. Adaptable to Aero Laboratories

   It should be compatible with both the very large and the very small equipment in the aero laboratories. It should also be capable of depicting color, as color often plays an important role in laboratory experimentation.

2. Suitable for Any Number

   It should be able to accommodate classes of up to 30 students with no loss in effectiveness.

3. Accessible to Absentees

   It should be easily accessible to anyone who, for either physical or mental reasons, was not exposed to some required material.

4. Easy to Utilize

   It should be easy to set up and operate and should be easily transportable.

5. Easy to Produce

   It should be of a nature such that it can be produced by an average person, inexpensively, and in a relatively short time.

6. Easy to Update

It should allow major or minor revisions to be made at a reasonable expense and with minimum endeavor.

B. SOLUTION

The first two requirements indicated quite strongly that the lecture package should be audio-visual in nature while the third indicated that it should not require the presence of an instructor in order to be used effectively. An investigation of the resources at the Naval Postgraduate School revealed the following as possible solutions to the problem.

1. Motion Picture

Although the motion picture adequately satisfied the first four requirements, it did not satisfy requirements 5 and 6. It was neither easy to produce nor was it easy to update. Consequently, it was not utilized in this endeavor. It was not precluded from future use, however, should the method selected prove ineffective.

2. Television

Television also fulfilled most of the requirements listed above. Its major drawbacks were that the Naval Postgraduate School facilities were not available in color and its location external to the Aeronautics building might hinder accessibility. Like the motion picture, it was held in abeyance to be used should facilities improve and/or the need dictate.

3. Tape-Slide

The tape-slide audio-visual method was the method which was ultimately selected as it fulfilled all of the requirements set forth previously. It was adaptable to aeronautics laboratories, suitable for any number of students, easily accessible to absentees, and easy to produce, utilize, and update.

III. EQUIPMENT AND PROCEDURE

A. EQUIPMENT

The Teaching Dynamics TD-201 audio-visual programmer was coupled with the Kodak Carousel remote control slide projector to obtain a portable, self-contained audio-visual studio (see Figure 1). This arrangement enabled the production and presentation of fully automatic and synchronized audio-visual programs.

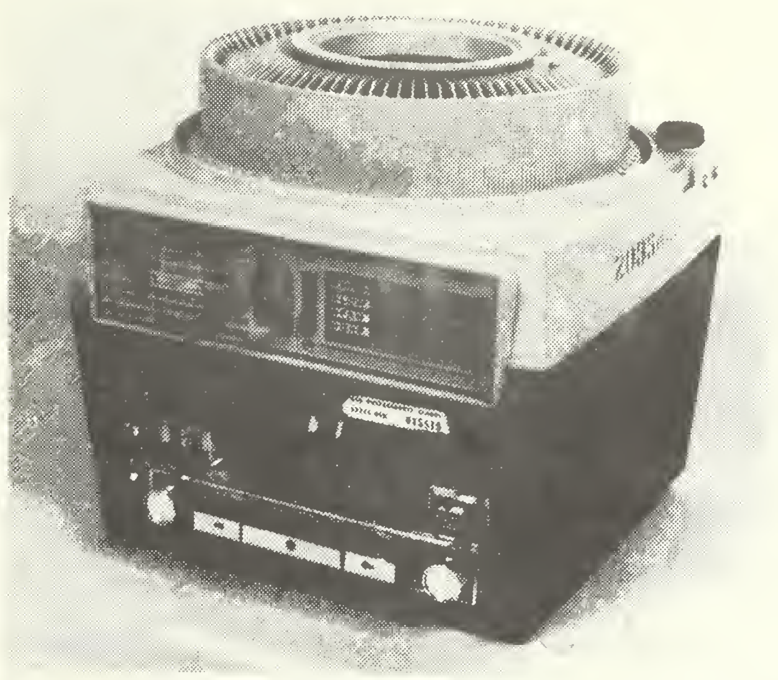

FIGURE 1

The system was designed around cassette tape with complete rewind and fast forward capabilities. The multi-track nature of the cassette tape made possible the recording of a monophonic program on one track and an inaudible pulse

at 120 Hertz on another track. Synchronization was obtained by means of the inaudible pulse which advanced the projector automatically.

This equipment can support fully automatic and continuous programs of up to one hour duration with a maximum of 140 slides. It can easily be transported as one unit since it weighs only 26 pounds and measures less than one foot per side.

The cost of the TD-201 was $283.00 and the cost of the Kodak Carousel was $96.00. Tape cassettes were obtained for less than one dollar each.

B. PROCEDURE

1. Objectives Defined

The questions "Why is the information important?", "Who will receive the information?", and "What use will be made of the information?" were considered in defining the objectives. The objectives were then limited to feasible outcomes and expressed in terms of desired learning outcomes for the student. A specific level of learning was assigned to each desired learning outcome (e.g., the students should understand the function of the settling chamber).

2. Script Written

a. Format

A general format was utilized to provide the framework for the script. This consisted of an introduction containing attention, motivation, and overview material, a

body, and a conclusion containing summary, remotivation, and closure material.

b. Outline

Specific ideas were listed as they came to mind or were found in the literature. These ideas were checked against the objectives and the superfluous ideas discarded. The remaining specific ideas were grouped under a small number of main ideas and the main ideas were examined for a logical pattern. The main ideas were then arranged to satisfy this pattern.

c. Development

In the development, the ideas were first established and then they were supported as necessary to accomplish the desired learning outcomes. The final step was to supply transitions between the ideas.

3. Slides Produced

First the script was keyed wherever there was an idea change in order that the sequence of slides be compatible with the sequence of ideas. Specific slides were then conceptualized for each keyed location and listed on a master slide list. Finally, the drawings and title graphics were carefully constructed and the necessary photographic work was done.

4. Program Refined

The slides were viewed in conjunction with the script, the shortcomings noted, and changes made to the script and/or

slides as necessary to enhance the effectiveness of the program. A smooth keyed script was then made in preparation for the reader.

5. Sound Recorded

Before the actual recording of the sound was made, it was found beneficial to practice reading the script orally until the proper pronunciation, inflection, and pace were mastered. After this was accomplished the sound was recorded and the inaudible pulses were keyed onto the tape.

6. Package Reviewed and Refined

The completed parts were assembled and the package was presented for critique. The new ideas which were generated were examined and the program altered to include those which would improve its effectiveness.

IV. RESULTS

The results are four individual tape slide lecture packages, each an entity in itself. The packages are available through the Educational Media Department or the Department of Aeronautics.

A. THE LOW-SPEED WIND TUNNEL--INTRODUCTION

This package comprises a 20-minute audio tape and sixty-nine 35 mm color slides. The keyed script and slide list are contained in Appendix A.

B. THE AEROLAB LOW-SPEED WIND TUNNEL--DESCRIPTION

This package comprises an 18-minute audio tape and seventy-eight 35 mm color slides. The keyed script and slide list are contained in Appendix B.

C. THE AEROLAB LOW-SPEED WIND TUNNEL--OPERATION

This package comprises an eight-minute audio tape and forty-four 35 mm color slides. The keyed script and slide list are contained in Appendix C.

D. TECHNICAL REPORT WRITING

This package comprises a 35-minute audio tape and one hundred thirty-six 35 mm color slides. The keyed script and proposed slide list are contained in Appendix D.

V. DISCUSSION

A. PROJECT GROWTH

The project as it was originally envisioned was to take the low-speed wind tunnel laboratory course and mold its individual weekly experiments into separate lecture packages. It soon became apparent that there was much information which was common to all of the experiments and this information could more appropriately appear by itself. Thus the emphasis was shifted to the four smaller lecture packages listed in the results. It is felt that other subjects appropriate for separate packages are: the operation of the wind tunnel balance, the application of wind tunnel boundary corrections, the proper construction of graphs, charts, and figures, and individual laboratory experiments.

B. PROGRAM LENGTH

There was a tendency throughout this endeavor to attempt to include too much diverse information in one program. The results were confusing and their usefulness limited. By narrowing the scope of each individual package, the probability of attaining the desired learning outcomes was increased and greater flexibility was offered to the user.

C. SCRIPT VS. GRAPHICS

Another common tendency was to discover or conceive interesting or amusing graphics and attempt to write the

script to complement the graphics. Although this resulted in interesting and amusing programs, the desired learning outcomes were not attained. A more practical procedure was to write the script first, including all of the necessary information and then devise graphics to complement the script.

D. THE THEME

The programs all start with lively background music and colorful interest slides. The subjects are then introduced with a series of slides depicting the launch of aircraft from the USS Enterprise, CVA 65. The introductions and conclusions are relatively short with most of the program devoted to developing the ideas in the body of the presentation. The programs are then brought to a close with the recovery of aircraft aboard the USS Enterprise. The music is brought into play again as acknowledgement slides are shown.

E. THE INTRODUCTORY PROGRAM

In the first version of this program, the slides and sound were not done professionally. Although the reaction to the program was quite favorable, it was decided that professional quality graphics and voice would cause it to be more widely and frequently used. Therefore, the program was refined by the Educational Media Department and the sound recorded on a master tape.

It has proven quite beneficial to use a master tape for the sound as it can be easily spliced to make minor changes without re-recording the entire script. In addition, it has become apparent that the narrator should be someone who is permanently available to avoid re-recording the entire script for minor alterations. The original slides are also kept on file at the Educational Media Department in case copies are needed. If copies are continually made from copies, the quality is degraded and the effectiveness of the slides reduced.

The predominant pattern for this program is one of time, starting with prehistoric man and continuing through the jet age. Its usefulness is not limited to aeronautics experts and it should prove beneficial to anyone who is interested in aeronautics.

F. THE AEROLAB PROGRAMS

These two programs were originally conceived as one, but were later separated in order to gain greater flexibility. They were designed to be shown initially in sequence; however, it is expected that the program on operation of the tunnel will subsequently become more frequently used.

The pattern for the program pertaining to description is one of flow. The program starts at the power section and moves downstream. It alternates diagrams and photographs in such a manner that interest is kept at a high level.

The pattern for the program pertaining to operation is one of sequence. The steps are described in the order in which they are expected to be performed. The slides consist predominantly of photographs of the various controls.

It is for the latter of these two programs than an easily transportable audio-visual apparatus with a stop action capability is most important. An alternative or perhaps a complement to this is that handouts be prepared to accompany the program. The user could avail himself of the information while at the site of the wind tunnel and have a much greater probability of successfully operating the tunnel.

G. TECHNICAL REPORT WRITING

So far the programs have been built on concrete facts and the subjects have a high interest factor. Technical report writing, on the other hand, is a subject which has very little appeal and concerns itself more with logic than with fact. Therefore, this program is somewhat experimental in nature. It has been suggested that this subject might more effectively be covered in a motion picture; however, the author contends that it can be covered quite satisfactorily with a tape-slide program.

The program covers all of the parts which might be included in a formal technical report and proceeds in order through the various parts stressing both their uniqueness

and their relation to other parts. It utilizes a cartoon character as the report writer and incorporates two voices, one of the narrator and the other of the report writer. Another innovation is that no voice is planned for the summary. Background music will provide the sound while the cartoon report writer thinks his way through the main points on colorful and pleasing slides.

It is felt that a handout is required to complement this program if it is to attain maximum effectiveness.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. The tape-slide lecture package is an effective means of presenting information pertaining to aero laboratories.

2. Several short presentations are more effective and useful than one long presentation.

3. Graphics which are professionally made enhance the effectiveness of the program.

4. A permament, locally available, professional quality narrator should be used to record the voice.

5. Master copies of the slides and tapes should be retained at the Educational Media Department.

6. At least one easily transportable tape-slide apparatus which is compatible with the programs should be retained in the Department of Aeronautics building.

7. Handouts would be helpful in complementing the individual programs.

B. RECOMMENDATIONS

1. It is recommended that the endeavor be continued as originally conceived to include individual laboratory experiments.

2. It is recommended that handouts be prepared to complement the existing programs.

3. It is recommended that The Department of Aeronautics obtain at least one tape-slide apparatus which is compatible with the existing programs.

APPENDIX A: THE LOW-SPEED WIND TUNNEL--INTRODUCTION

● 11

For many, many years man lived at the bottom of an ocean of air without really capitalizing on its full potential. ● 12 He observed the birds in flight and constantly marvelled at their wondrous gift. ● 13 Almost as soon as forms of expression appeared, the theme of wings was there. ● 14 Gradually this idle dreaming gave way to action and man began to fasten artificial wings onto himself. ● 15 We still hear faint reverberating echoes of the disastrous results of his first flights. ● 16 Man soon began to realize the importance of testing the flight characteristics of his inventions before he ultimately made them part of himself and hurled himself into space. ● 17 Thus the concept of wind tunnel testing was born. Even in today's jet age, few of us would consider flying this remarkable machine without first gathering extensive wind tunnel data on it. ● 18

This brief introduction to the low-speed wind tunnel will include: ● 19 a look at the major historical developments in wind tunnel design, ● 20 a look at low-speed wind tunnel classification, ● 21 a discussion of some special use low-speed wind tunnels. ● 22

During the nineteenth century, the nature of studies of air motion around bodies began to change. The investigations were expanded to include the component of force acting perpendicular to the wind direction, that component which we now know as lift. ● 23 The first investigations of this type

were carried out using natural winds and models mounted on rotating arms. The most outstanding contributions along these lines were made by Otto Lilienthal in 1871. Since the natural winds were very unsteady and the rotating arm apparatus had the model traveling in its own wake after one revolution, and since both methods rendered force measurement difficult, the need for more sophisticated methods became evident.[24]

This led to what was probably the first wind tunnel, constructed by Francis H. Wenham in England in 1871. Wenham's tunnel consisted of a wooden trunk 10 feet long and 18 inches square through which air was blown by a steam engine driven fan. The test models were mounted on a shielded balance which was placed about two feet from the exit of the trunk. The winds in Wenham's tunnel were also very unsteady and the need for further refinement persisted.[25]

The next significant contribution was made by Horatio Phillips, also in England, in 1874. In order to avoid the problems encountered by Wenham, he built a single-pass induction tunnel utilizing a steam jet at the throat. The tunnel consisted of a wooden trunk as the test section followed by a sheet iron nozzle. The model and balance system were mounted on a board which could be slid into the test section. Phillips also incorporated a wind-gauge in his tunnel and used fine ribbons to determine flow patterns.[26]

Perhaps the most famous pioneers of flight were Wilbur and Orville Wright. Reports of Lilienthal's experiments

aroused their interest in flight and in the fall of 1901 they built a wind tunnel. The Wright Brothers' wind tunnel measured 16 inches square by six feet long and incorporated a honeycomb to reduce the turbulence of the air. With this tunnel the Wright Brothers obtained what was probably the first useful pressure distribution data. This work proved that the leading edge of the wing should not be sharp and that very high camber did not necessarily produce the best results.[27]

Another major development was made in Germany in 1903 with the first of the Goettingen tunnels designed by Prandtl. This was the first closed-circuit or return type tunnel. It had a uniform cross-sectional area throughout and incorporated turning vanes at the corners and honeycombs for air flow straightening.[28]

The next step toward modern wind tunnel design was made in England in 1912 with the construction of the Teddington tunnel. The major difference in the Teddington tunnel was the the use of a slatted diffuser. This was an attempt to reduce the unsteadiness of flow caused by disturbances in the room in which the tunnel was located and to obtain a lower energy loss. This resulted in much smoother flows.[29]

The prototype of the modern return type tunnel was built in Germany in 1917. The second of the Goettingen tunnels, it included all of the essential features of present-day low-speed wind tunnels. It incorporated a diffuser after

the test section to reconvert kinetic energy into pressure energy and flow straightening vanes following the fan to remove the twist imparted by the fan.[30] Turning vanes were used at the corners to reduce flow losses which would otherwise result from the large turning angle.[31] A settling chamber including honeycomb was used to reduce the velocity. This eventually enabled the production of a more uniform flow with a lower level of turbulence in the test section. The settling chamber was followed by the contraction cone to give a continuously increasing velocity up to the test section[32] and finally the test section itself which, in the second Goettingen tunnel, was in the form of an open jet.[33]

This essentially brings us up to modern times and we will now consider wind tunnel classification. There are two basic types of low-speed wind tunnels.[34] The first, called an open-circuit tunnel, has no guided return for the air. Although the open-circuit tunnel is inherently efficient it has some major disadvantages which cause it to have limited use today.[35] First, it is at the whim of the outside weather. Rain, snow, temperature, and gusty winds have a large effect on its operation. Second, it is extremely noisy. Third, it may ingest foreign objects in the form of dirt, insects or birds.[36]

Consequently, the overwhelming percentage of low-speed wind tunnels today are of the second type--the closed-circuit tunnel. It has, as its name implies, a continuous

path for the air. The closed-circuit tunnel may be further broken down into three subtypes.[37] The single-return is by far the most prevalent today. It has only one passage for the circulation of air and has as its major advantage the fact that the relatively undisturbed flow in the center of the passage is the air which passes over the test model.[38]

The double-return tunnel has two passages for the circulation of air.[39] Its major drawback is that the particular air that scrapes along the walls of the return passage forms the center of the jet and hence passes directly over the test model. A further disadvantage is that a variation in velocity distribution may result from yawing a large model. The flow deflected to one side could conceivably stay there for the entire circuit.[40]

The annular-return wind tunnel has the same essential features as the double-return type with the exception that it incorporates a 360° outer ring for the circulation of air.[41] The annular-return tunnel is subject to the same major disadvantage as the double-return tunnel--the disturbed flow at the walls ultimately passes over the test model.[42]

Further identification of wind tunnels may be made through cross-sectional form of the test section. It may be square, rectangular, polygonal, elliptic, or circular.[43] Another distinction may be made as to whether the test section is completely walled in--closed jet, or consists simply of an open space from the contraction cone to the diffuser-open jet.[44]

A listing of some of the NASA tunnels presently in use may help to illustrate the preceding discussion. Three examples will be given of tunnels which serve completely different functions.[45]

First, the free-flight tunnel is an open-circuit tunnel with a closed jet. It has a maximum velocity of 60 miles per hour and a test section in the shape of a twelve-sided polygon.[46] Second, the full-scale tunnel is of the double-return design and has an open jet. Its maximum velocity is 110 miles per hour in an elliptic test section.[47] Third, the ice tunnel is a single-return tunnel with a closed jet. It can operate up to 350 miles per hour and incorporates a rectangular test section.[48] NASA has many more special-use wind tunnels and some of the more interesting ones will now be discussed.[49]

The airspin tunnel was developed to assist in solving problems of non-steady motion of aircraft and especially of spin. Airspin tunnels are installed vertically with air flowing upward of sufficient speed so that scaled models of aircraft can, while spinning, be held suspended for observation of spin recovery. In the contraction cone, settling chamber and around the test section are nets installed for catching the model when the flow is stopped.[50]

In free-flight tunnels models fly under the influence of gravitational, aerodynamic, and inertia forces. The control surfaces of the model are adjusted by remote controls. At the beginning of the test the model is installed stationary.

on the horizontal floor of the test section. The flow velocity is then increased until the model can remotely be rotated to liftoff attitude and become airborne. Various glide paths can be simulated by changing the tilt of the tunnel and its airspeed.[51]

The variable-density tunnel was designed in order to attain high Reynolds numbers without either extremely large models or very high speeds. For example, to operate at the correct Reynolds number, a 1/4 scale model of a 200-mile-per-hour airplane would require a tunnel speed of 800 miles per hour. This is well into the compressibility range and, in addition, power requirements might be prohibitive. By pressurizing the test section to four atmospheres the tests can be run at 200 miles per hour for a 1/4 scale model and obtain full scale Reynolds numbers.[52]

In the ice tunnel, models are subjected to icing conditions and methods for the prevention of icing and ice removal are studied. It consists of the normal wind tunnel components with the addition of a large capacity cooler just before the settling chamber and water spray nozzles in the settling chamber itself. The ice tunnel experiences all the usual wind tunnel aerodynamic difficulties plus the addition of ice.[53]

Smoke tunnels introduce a different approach to studying air flow around models. In this type of tunnel smoke ejectors just before the model emit cleaned smoke in streamer form.

These smoke streamers make possible the visualization of the pattern and characteristics of flow around bodies at small velocities. [54]

There are, of course, other types of wind tunnels which include [55] nearsonic --those which operate near but below the speed of sound, [56] transonic--those which operate at the speed of sound, [57] supersonic--those which operate above the speed of sound but with relatively low mach numbers, [58] and hypersonic--those which operate at mach numbers greater than five. These tunnels will not be discussed in detail as they are beyond the scope of this presentation and are only mentioned as a matter of interest. [59]

This introductory presentation has briefly considered the following items. [60] The history of wind tunnels with a brief look at the tunnels of Francis Wenham, Horatio Phillips, and the Wright Brothers. The first Goettingen and Teddington tunnels were discussed followed by the second Goettingen tunnel which was the prototype of present-day low-speed wind tunnels. [61] Next, wind tunnel classification was considered, the two basic types being open-circuit and closed-circuit with the closed-circuit being further classified into single-return, double-return, and annular-return. [62] Finally, special use low-speed tunnels were considered--the airspin, free-flight, variable-density, ice, and smoke tunnels. [63]

Remember that even in today's supersonic age, the low-speed wind tunnel still plays an important role as man has

not yet devised a way for aircraft to become airborne or to land safely without passing through the low-speed flight regime.[64]

SLIDE LIST

1. OPAQUE
2. TARGET SLIDE
3. DIAGRAM OF FLOW OVER AIRFOIL SECTION
4. SILHOUETTE OF SUPERSONIC AIRCRAFT
5. FRONT VIEW OF JET ENGINE
6. AIRCRAFT TAXIING TO CATAPULT
7. AIRCRAFT AT FULL POWER ON CATAPULT
8. AIRCRAFT PASSING OVER BOW
9. "THE DEPARTMENT OF AERONAUTICS PRESENTS"
10. "AN INTRODUCTION TO LOW-SPEED WIND TUNNELS"
11. PRIMITIVE MAN OBSERVING LEAVES FALLING
12. MAN OBSERVING BIRDS IN FLIGHT
13. EARLY ART WORK DEPICTING WINGED CREATURES
14. MAN LAUNCHING WITH ARTIFICIAL WINGS
15. LATER LAUNCH WITH ARTIFICIAL WINGS
16. MAN AND WINGS IN CRASH SCENE
17. CARTOON OF TEAKETTLE JET
18. "OVERVIEW"
19. "OVERVIEW--HISTORY"
20. "OVERVIEW--HISTORY, CLASSIFICATION"
21. "OVERVIEW--HISTORY, CLASSIFICATION, SPECIAL USE LOW-SPEED WIND TUNNELS"
22. DIAGRAM OF WING WITH LIFT, DRAG, AND RELATIVE WIND VECTORS
23. DIAGRAM OF ROTATING ARM APPARATUS
24. DIAGRAM OF WENHAM'S TUNNEL

25. DIAGRAM OF PHILLIPS' TUNNEL

26. DIAGRAM OF WRIGHT BROTHERS' TUNNEL

27. DIAGRAM OF FIRST GOETTINGEN TUNNEL

28. DIAGRAM OF TEDDINGTON TUNNEL

29. DIAGRAM OF SECOND GOETTINGEN TUNNEL

30. SAME AS ABOVE WITH MORE ITEMS LABELLED

31. SAME AS ABOVE WITH MORE ITEMS LABELLED

32. SAME AS ABOVE WITH MORE ITEMS LABELLED

33. "CLASSIFICATION"

34. DIAGRAM OF OPEN-CIRCUIT TUNNEL

35. DIAGRAM OF OPEN-CIRCUIT TUNNEL WITH DISADVANTAGES

36. DIAGRAM OF CLOSED-CIRCUIT TUNNEL

37. DIAGRAM OF SINGLE-RETURN TUNNEL

38. DIAGRAM OF DOUBLE-RETURN TUNNEL

39. DIAGRAM OF DOUBLE-RETURN TUNNEL WITH DISADVANTAGES

40. DIAGRAM OF ANNULAR-RETURN TUNNEL

41. DIAGRAM OF ANNULAR-RETURN TUNNEL WITH DISADVANTAGES

42. "FURTHER IDENTIFICATION--CROSS-SECTIONAL FORM"

43. "FURTHER IDENTIFICATION--CROSS-SECTIONAL FORM, OPEN OR CLOSED JET"

44. MAIN HEADING "NASA TUNNELS" WITH SUBHEADINGS "TUNNEL, TYPE, JET, VMAX, JET SHAPE"

45. SAME AS ABOVE WITH SPECIFICS OF FREE-FLIGHT TUNNEL ADDED

46. SAME AS ABOVE WITH SPECIFICS OF FULL-SCALE TUNNEL ADDED

47. SAME AS ABOVE WITH SPECIFICS OF ICE TUNNEL ADDED

48. "SPECIAL USE WIND TUNNELS"

49. DIAGRAM OF AIRSPIN TUNNEL

50. DIAGRAM OF FREE-FLIGHT TUNNEL

51. DIAGRAM OF VARIABLE-DENSITY TUNNEL

52. DIAGRAM OF ICE TUNNEL

53. DIAGRAM OF SMOKE TUNNEL

54. "OTHER TYPES"

55. "OTHER TYPES--NEARSONIC"

56. "OTHER TYPES--NEARSONIC,TRANSONIC"

57. "OTHER TYPES--NEARSONIC, TRANSONIC, SUPERSONIC"

58. "OTHER TYPES--NEARSONIC, TRANSONIC, SUPERSONIC, HYPERSONIC"

59. "SUMMARY"

60. "FRANCIS WENHAM, HORATIO PHILLIPS, WRIGHT BROTHERS, FIRST GOETTINGEN, TEDDINGTON, SECOND GOETTINGEN"

61. "OPEN CIRCUIT, CLOSED CIRCUIT--SINGLE-RETURN, DOUBLE-RETURN, ANNULAR-RETURN"

62. "AIRSPIN, FREE-FLIGHT, VARIABLE DENSITY, ICE, SMOKE"

63. DIAGRAM OF AIRFOIL SECTION IN SUBSONIC FLOW

64. AIRCRAFT IN GROOVE

65. AIRCRAFT PASSING OVER ROUNDDOWN

66. AIRCRAFT IN THE ARRESTING GEAR

67. "A PALKA-ZORRO ENTERPRISE"

68. "PRODUCED BY THE EDUCATIONAL MEDIA DEPARTMENT"

69. NAVAL POSTGRADUATE SCHOOL SEAL

APPENDIX B: THE AEROLAB LOW-SPEED WIND TUNNEL--DESCRIPTION

11

Useful information for aerodynamic design may be obtained from a variety of sources such as rocket sleds, water tunnels, whirling arms, shock tubes, rocket flights, and ballistic 12 ranges. The main method of research, however, which determines the success of aerodynamics as a science and its wide application in many fields of technology is testing in wind tunnels. The wind tunnel is a device for testing aircraft and their components in a controlled 13 airstream and it provides a means of assuring that the first flight of an aircraft will not be its last. It is extremely important, therefore, that the student of aeronautics understand the principle of operation of the wind tunnel and the functions of its component 14 parts.

The objective of this presentation is to acquaint the student with the Naval Postgraduate School low-speed wind tunnel and the functions of its 15 components. To accomplish this objective, the inside of the tunnel will be explored and the items encountered discussed in detail.

This will include: 16 the power section consisting of the fan, motor and 17 transmission, the flow straightening and turning 18 vanes, the diffusing 19 sections, the settling 20 chamber, the 21 screens, the contraction 22 cone, the test 23 section, flow measuring 24 components.

The low-speed wind tunnel used by Aeronautical Engineering students at the Naval Postgraduate School is located in the

northwest corner of the basement of Halligan Hall.[25] It was designed by the Aerolab Development Company of Pasadena, California, and installed at the Navy School in the mid 1950's.[26] The Aerolab low-speed wind tunnel is a single-return tunnel measuring 64 feet in length and between 21-1/2 and 25-1/2 feet in width.[27]

The power section of the tunnel comprises a 100-horsepower electric motor coupled to a three-bladed variable-pitch fan by a four-speed Dodge truck transmission.[28]

It is customary in wind tunnels to power the fan with an electric motor. The initial expense is greater than that for an internal-combustion engine of equal power; however, the operating and maintenance costs are lower, control is far superior and operation is simpler and more dependable.[29]

Although the fan closely resembles an airplane propeller, the presence of the tunnel walls make the characteristics of the fan significantly different from those of a propeller. Since the fan is operated in a duct of essentially constant cross-sectional area, its result is to increase the pressure of the air rather than the velocity as an airplane propeller does. Major factors affecting fan design are tip clearance, tip diameter to root diameter, blade camber, and blade twist.[30]

The four-speed Dodge transmission was installed by the staff of the Postgraduate School when it was discovered that the straight-drive original equipment did not adequately meet the requirements for the tunnel. With the incorporation of

the transmission, it became possible to obtain smooth operation for all tunnel speeds up to approximately 200 miles per hour.[31]

Directly downstream of the fan is located a set of stator blades which is commonly called the flow straightener. The flow straightener removes the twist imparted by the fan, thus reducing the losses and turbulence which would otherwise occur.[32] The number of blades in the flow straightener should be different from an integer multiple of those in the fan so that pulsations caused when the fan blades pass the stator blades will not all occur at the same moment. In this tunnel there are eight stator blades opposing the swirl imparted by three fan blades.[33]

When air flows around the turns in a wind tunnel, appreciable loss may occur if the design is poor. The most effective means of reducing this loss is to install turning vanes in the bend.[34] The simplest type of turning vane is the plane curved sheet which is the type in use here. This type must be oriented very precisely or separation will occur at the leading edge.[35]

In the low-speed wind tunnel a large portion of the ducting is used to diffuse the air. The return passage serves this purpose[36] in addition to completing the circuit and ultimately returning the air to the test section.[37]

The flow continues through two more sets of turning vanes of the same type as those previously mentioned and

into the settling chamber. Here the cross-sectional area of the tunnel is the greatest; hence the velocity is the least. 38 The larger the cross-sectional area of the settling chamber compared to that of the test section, the greater will be the probability of low turbulence air in the test section. 39

Two screens are installed in the settling chamber to aid in the production of smoother test section flows. 40 These screens are specially constructed of fine wire and are positioned approximately six inches apart. Large turbulent fluctuations are broken down into smaller ones of lower energy by the screens and the smaller fluctuations are ultimately dissipated as heat energy. 41

The principal function of the contraction cone is the acceleration of the low-speed air to the velocity required in the test section. 42 In addition, because of its continually decreasing cross section, the contraction cone tends to produce a more uniform distribution of velocity in the test section. 43

The test section of the Naval Postgraduate School low-speed wind tunnel has a cross-sectional area of 9.88 square feet, approximately one-tenth that of the settling chamber. 44 It is basically of rectangular design, but is modified with frosted light glass fillets to provide illumination of the test model. The walls of the test section are slightly divergent to counteract the effective contraction due to

boundary layer growth. 45 Hinged windows on either side of the test section permit easy access into the tunnel and unobstructed viewing of the test model during tunnel operation. 46

This test section, like that of most low-speed wind tunnels, operates at atmospheric pressure. Since the velocity is greatest here, the pressure is lowest, which means that the pressure everywhere else in the circuit is above atmospheric; 47 consequently, some leakage will occur through the duct walls, since it is virtually impossible to make the tunnel airtight. If nothing were done to correct this, the pressure in the test section would drop below atmospheric resulting in leakage into the tunnel at this critical point. 48 Hence, a breather slot is installed immediately downstream of the test section. 49 This slot, approximately five one-hundredths tunnel diameters wide and extending completely around the tunnel, allows air to flow into the circuit to make up leakage losses and insures that the test section remains at a uniform pressure. 50

The diffuser of the tunnel is a gradually widening duct downstream of the test section, serving for the efficient conversion of the kinetic energy of the air into pressure energy. Thus it serves to prevent excessive friction losses due to high flow velocities. 51 Although most of the ducting in the tunnel serves to diffuse the air, the term "diffuser" is commonly applied only to that part of the circuit situated between the test section and the first corner. 52

In the diffuser there is a protective screen constructed of heavy[53] wire. The sole function of this screen is to protect the turning vanes and fan from damage should there be a model failure.[54]

Located on the north wall of the settling chamber is a temperature gauge which is connected to a thermocouple extending into the tunnel.[55] This gauge indicates the temperature of the air in the settling chamber in degrees Fahrenheit.[56]

Static pressure taps are placed at two sections of the wind tunnel sufficiently far upstream of the test section so that pressure changes induced by the model are negligible. There are four static taps, situated one on each wall, at a section of the settling chamber just downstream of the screens and four more at a section in the contraction cone near the test section.[57] The taps at each section are connected to a common manifold so that possible peculiarities of the flow at some point may not greatly influence the results.[58] These static ports are connected to a manometer which, when properly calibrated, can give an accurate indication of test section velocity without obstructing the flow.[59]

Another integral part of the Aerolab low-speed wind tunnel is a pitot-static tube located inside the contraction cone near one vertical wall.[60] The static and total pressure leads are connected to an airspeed indicator to give a rough estimate of tunnel velocity.[61] The pressure leads from the pitot-static tube are also routed to a

common board from which they may be attached to a manometer for a more accurate measurement of velocity at this point.[62] Because of its location outside the test section and near a tunnel wall, this pitot-static tube is seldom used for anything more than a rough approximation of test section velocity.[63]

During this brief journey through the Aerolab low-speed wind tunnel the following items were encountered:[64]

The power section consisting of the motor, transmission, and fan which yields tunnel speeds up to 200 miles per hour.[65]

The flow straightening and turning vanes which help to reduce energy losses.[66]

The diffusing sections which change kinetic energy into pressure energy, thus reducing friction losses.[67]

The settling chamber which has the largest cross-sectional area and serves to even the flow.[68]

The screens, two of which help reduce turbulence while the other prevents fod to the fan and turning vanes.[69]

The contraction cone which accelerates the flow to test section velocity.[70]

The test section itself which is rectangular with light fillets and is enclosed by hinged windows.[71]

And the flow measuring components comprising the temperature guage, static ports, and pitot-static tube.[72]

It is important to remember that the wind tunnel is an aerodynamicist's tool which, if used properly, will help to assure a long and happy aircraft life.[73]

SLIDE LIST

1. OPAQUE
2. TARGET SLIDE
3. PHOTOGRAPH OF SPECIAL NASA TUNNEL
4. PHOTOGRAPH OF SPECIAL NASA TUNNEL
5. PHOTOGRAPH OF SPECIAL NASA TUNNEL
6. AIRCRAFT TAXIING TO CATAPULT
7. AIRCRAFT AT FULL POWER ON CATAPULT
8. AIRCRAFT PASSING OVER BOW
9. "THE DEPARTMENT OF AERONAUTICS PRESENTS"
10. "A DESCRIPTION OF THE AEROLAB LOW-SPEED WIND TUNNEL"
11. PICTURE OF ROCKET SLED, WATER TUNNEL, WHIRLING ARM, SHOCK TUBE, ROCKET, AND BALLISTIC RANGE
12. SKETCH OF WIND TUNNEL
13. SKETCH OF WIND TUNNEL AND AIRBORNE AIRCRAFT
14. "OBJECTIVE--TO ACQUAINT THE STUDENT WITH THE AEROLAB LOW-SPEED WIND TUNNEL"
15. DIAGRAM OF AEROLAB TUNNEL
16. DIAGRAM OF AEROLAB TUNNEL HIGHLIGHTING POWER SECTION
17. DIAGRAM OF AEROLAB TUNNEL HIGHLIGHTING VANES
18. DIAGRAM OF AEROLAB TUNNEL HIGHLIGHTING DIFFUSING SECTIONS
19. DIAGRAM OF AEROLAB TUNNEL HIGHLIGHTING SETTLING CHAMBER
20. DIAGRAM OF AEROLAB TUNNEL HIGHLIGHTING SCREENS
21. DIAGRAM OF AEROLAB TUNNEL HIGHLIGHTING CONTRACTION CONE
22. DIAGRAM OF AEROLAB TUNNEL HIGHLIGHTING TEST SECTION
23. DIAGRAM OF AEROLAB TUNNEL HIGHLIGHTING FLOW MEASURING COMPONENTS

75. AIRCRAFT IN THE ARRESTING GEAR

76. "A PALKA-ZORRO ENTERPRISE"

77. "PRODUCED BY THE EDUCATIONAL MEDIA DEPARTMENT"

78. NAVAL POSTGRADUATE SCHOOL SEAL

APPENDIX C: THE AEROLAB LOW-SPEED WIND TUNNEL--OPERATION

10

In the course of laboratory experimentation, the researcher is often called upon to set up and operate his own equipment or to guide others in this endeavor. In low-speed wind tunnel testing, then, it would be necessary for the researcher to be able to operate the wind tunnel. 11

The objective of this presentation is to instruct the student in the operation of the Naval Postgraduate School low-speed wind tunnel. 12 The student will be exposed to the proper method of starting the tunnel, varying its speed, and stopping the tunnel. 13

The first step in the starting sequence is to ascertain that the transmission is in the proper gear for the tunnel speed desired. 14 This can be accomplished by consulting the available chart showing maximum tunnel speeds for each gear, 15 and physically checking the transmission to see that the appropriate gear has been selected. It is important that this is done before starting the tunnel as the transmission is not equipped with a clutch and the power section must be completely stopped in order to change gears. 16

The second step is to place the power supply switch in the fully up or on position. 17 If the unit is plugged in, the power light should come on. If it does not, a technician should be consulted. The two rheostats to the right of the power supply switch will be discussed later. 18

Once power has been supplied, two lights on the control head will illuminate. The red light is an interlock light; however, since the interlock system is not incorporated in this tunnel, its illumination is meaningless. The green light is a propeller position light and its illumination indicates that the propeller is in some position other than minimum pitch. [19]

The next step in the starting sequence is to depress the start button on the control head and hold it in this position. [20] This will automatically set the propeller to low pitch, the propeller position light will go out and the tunnel will start. The start button may then be released. [21]

Four toggle switches are provided on the control head for varying the tunnel speed. [22] Two switched labelled "coarse" and "fine" "up" are provided for increasing the pitch of the fan blades. [23] This corresponds to an increase in tunnel speed. [24] Two identical buttons labelled "coarse" and "fine" "down" are provided for decreasing the pitch of the fan blades. [25] This corresponds to a decrease in tunnel speed. [26] As their names imply, the coarse switches are used to effect large changes in tunnel velocity and the fine switches are used for minor adjustments as the desired velocity is approached. [27] The rheostats located on the power supply control the rate at which the propeller pitch may be changed. These rheostats have been set by a technician and there is seldom any reason for changing them. [28]

After the experimental work has been completed, the final step will be to stop the tunnel. [29] This may be accomplished by a momentary activation of the stop button [30] after which the main power supply should also be secured. [31]

For emergency stops of the tunnel there are switch boxes located on either side of the test section which are painted bright red. Changing the position of either of these switches will interrupt the electrical power to the motor and cause the tunnel to stop. [32] The switch positioned below the emergency stop switch on the control side of the tunnel is for operation of the test section lights. [33]

Briefly recapping the steps in the operation of the tunnel: [34]

First select the appropriate gear for the speed desired. [35]

Then turn the power switch on and depress and hold the start button until the tunnel starts. [36]

The speed may be varied by proper use of the four toggle switches on the control head. "Up" increases tunnel speed; "down" decreases tunnel speed. [37]

Finally, to stop the tunnel, momentarily depress the stop button and secure the main power supply. [38]

With these few simple steps in mind, the student should be able to operate the Aerolab low-speed wind tunnel effectively and efficiently, thus making more time available for the other portions of his research. [39]

SLIDE LIST

1. OPAQUE
2. TARGET SLIDE
3. PHOTOGRAPH OF NASA TUNNEL
4. PHOTOGRAPH OF NASA TUNNEL
5. AIRCRAFT TAXIING TO CATAPULT
6. AIRCRAFT AT FULL POWER ON CATAPULT
7. AIRCRAFT PASSING OVER BOW
8. "THE DEPARTMENT OF AERONAUTICS PRESENTS"
9. "OPERATING THE AEROLAB LOW-SPEED WIND TUNNEL
10. PHOTOGRAPH OF PUZZLED RESEARCHER
11. "OBJECTIVE--OPERATE THE TUNNEL"
12. "OBJECTIVE--OPERATE THE TUNNEL--START, VARY SPEED, STOP"
13. "STARTING--DESIRED GEAR"
14. PHOTOGRAPH OF GEAR SELECTION CHART
15. PHOTOGRAPH OF TRANSMISSION
16. "STARTING--1. DESIRED GEAR, 2. POWER ON"
17. PHOTOGRAPH OF POWER SUPPLY
18. PHOTOGRAPH OF CONTROL HEAD WITH LIGHT ON
19. "STARTING--1. DESIRED GEAR, 2. POWER ON, 3. DEPRESS START BUTTON"
20. PHOTOGRAPH OF CONTROL HEAD WITH LIGHT OUT
21. "VARYING TUNNEL SPEED"
22. PHOTOGRAPH OF TWO "UP" TOGGLE SWITCHES
23. PHOTOGRAPH OF FAN BLADES AT HIGH PITCH
24. PHOTOGRAPH OF TWO "DOWN" TOGGLE SWITCHES

25. PHOTOGRAPH OF FAN BLADES AT LOW PITCH

26. PHOTOGRAPH OF FOUR TOGGLE SWITCHES

27. PHOTOGRAPH OF RHEOSTATS

28. "STOPPING--1. DEPRESS STOP BUTTON, 2. SECURE POWER SUPPLY"

29. PHOTOGRAPH OF STOP BUTTON

30. PHOTOGRAPH OF POWER SUPPLY SWITCH OFF

31. PHOTOGRAPH OF EMERGENCY STOP BUTTONS

32. PHOTOGRAPH OF TEST SECTION LIGHTS SWITCH

33. "SUMMARY"

34. PHOTOGRAPH OF SLIDE 13, GEAR SELECTION CHART, TRANSMISSION

35. PHOTOGRAPH OF SLIDE 19, POWER SUPPLY, CONTROL HEAD

36. PHOTOGRAPH OF SLIDE 21, CONTROL HEAD

37. PHOTOGRAPH OF SLIDE 28, CONTROL HEAD, POWER SUPPLY

38. PHOTOGRAPH OF CONFIDENT RESEARCHER

39. AIRCRAFT IN GROOVE

40. AIRCRAFT PASSING OVER ROUNDDOWN

41. AIRCRAFT IN ARRESTING GEAR

42. "A PALKA-ZORRO ENTERPRISE"

43. "PRODUCED BY THE EDUCATIONAL MEDIA DEPARTMENT"

44. NAVAL POSTGRADUATE SCHOOL SEAL

APPENDIX D: TECHNICAL REPORT WRITING

10

The mere discovery and interpretation of facts do not complete the work of the investigator. 11 In order that the results may be used by others, they must be disclosed either orally or in writing. 12 The effectiveness with which they may be used depends as much on the clarity and completeness of disclosure as on the reliability of the data and the intelligence with which they are interpreted. 13 Thousands of man hours are wasted each year attempting to decipher poorly organized and poorly written reports. Therefore, it is essential that every effort be made by the author to produce a report which is accurate, logical, clear and concise. 14

The purpose of this presentation is to introduce the student to the technical report and give him guidelines for its construction. While no definite, iron-clad rules of procedure can be laid down for the preparation of all reports, there are some features that are common to most because they contribute to clarity and convenience of use. These are the features which will be emphasized in the ensuing discussion. 15

First we will take a brief look at factors which must be considered in planning the report. Then we will examine in detail the various parts of the report, stressing both their uniqueness and their relation to other parts. 16

The planning for the preparation of a report should begin as soon as the request has been made for an

investigation which requires a report. [17] First one must consider the purpose of the report--that is "Who will read the report?" and "What use will they make of it?" The answers to these two questions affect everything about the report: [18] the order in which the material is presented, the number and complexity of the tables, the type and detail of the graphs and illustrations, and the material which is included in the appendices. [19]

Possible readers of the technical report include: Technical colleagues--men who work daily in the same field as the author and have detailed knowledge of the subject of the report, [20] Specialists in related technical fields--persons who have only a general knowledge of what the author does, [21] Management--those above the author in the chain of command, [22] Laymen--which includes all persons not familiar with the author's field. [23] Ideally the report should be written for only one group of readers. To do otherwise inevitably introduces compromises in the presentation. [24]

Possible uses for the technical report may include: A basis for a more detailed investigation in the same field, [25] a vehicle for introducing an important discovery, [26] a means of stimulating interest in the author's field. [27]

Other factors which must be considered are the amount of time available in which to prepare the report and the money and materials available for the writing, reviewing, and production of the report. [28]

Let us now turn our attention to the actual structure of the report. A well organized report is divided into easily recognizable parts arranged in an effectual sequence. From usage these parts have become somewhat standardized, but should be adapted to the material and the purpose for which the report is written.[29] There is no need to try for a smooth flow from one part to the next as is often done in narrative writing. In technical report writing, the author makes it clear when he shifts from one part to another by inserting a descriptive heading and then proceeds with his exposition in as direct a manner as possible.[30]

The number of parts in a report depends upon its length and the complexity of the material as well as its purpose.[31] A formal technical report includes many standard parts, each distinct from the others.[32] In an informal technical report, many of the parts are omitted and others are combined.[33] In developing the plan for the technical report, all parts should be considered and the unnecessary ones then omitted or combined with others.[34]

The parts of the technical report are generally considered in three groups: the front matter, the report proper, and the supplementary matter.[35]

The front matter is normally on pages numbered with lower case Roman numerals and the sections are usually short--only one or two pages. In a formal technical report, however, they should be treated as major sections and each should start on a new page.[36]

The report proper is the heart of the report. It contains all information which is essential to an understanding of the report. The pages are numbered with Arabic numerals and again in the formal report each section should start on a new page. [37]

The supplementary matter is miscellaneous information that would be useful to some of the readers of the report, but is not essential to the basic exposition. These pages are numbered with Arabic numerals starting where the report proper left off. [38]

The title page is usually the first sheet of the report considered to be page Roman numeral one; however, the numeral does not actually appear on the page. [39] Since this gives the reader his first inkling as to the subject of the report, the title page must state the subject as fully and forcefully as possible. The title should contain everything needed to give a truthful description of the report, nothing more and nothing less. [40] Some titles are short enough to be written on one line, [41] others require two or more lines. [42] Project numbers, author, date, name of issuing organization and location are other items normally included on the title page and they should be spaced to give an informative, neat, and balanced page. The title page is always a right hand page. [43]

A letter of transmittal is addressed to the primary recipient of the report and serves to identify the report and formally present it to the recipient. [44] The letter of

transmittal should be prepared in standard business correspondence style under the official letterhead of the author's organization. If the report is to be distributed to other than the management of the organization that financed the project, it is best not to include a letter of transmittal as an integral part of the report. Instead a foreword or preface can be used to accomplish much the same thing.[45]

Both the foreword and the preface are considered front matter and they should be separate from the report proper. They are usually written after the rest of the report has been completed.[46] The principal difference between a preface and a foreword is that a preface is written by the author, whereas a foreword customarily is written by a second party, usually an expert in the field served by the report and can contain praise which modesty forbids from the author.[47] In the preface the author may explain why he wrote the report in the way that he did, for whom he wrote it, and how he expects the information to be used. Acknowledgements may also be made in the preface. Note that the preface introduces the report itself, not the subject of the report. Introducing the subject is the role of the introduction.[48]

The content of the foreword should be in the nature of information supplied by someone looking at the report over the author's shoulder. It might include comment on such items as the quality or background of the work, the success

or skill of the author in his profession, and the reason the work was performed.[49] Since a majority of report readers read neither the preface nor the foreword, these sections should not contain anything essential to the understanding of the report unless the information is repeated in the report proper.[50]

Both the table of contents and the index serve to assist the reader in locating particular portions of a report; however, they possess some basic differences.[51]

A table of contents is located at the beginning of the report and indicates to the reader the method of organization of the report and tells him on what page to find a particular section. A well planned table of contents can save the users a considerable amount of time.[52]

The index is situated at the end of the report. It provides no clue to the organization of the report, but rather tells the reader the specific pages on which a subject is mentioned. It gives no indication of the detail in which an item is discussed nor does it key the reader to illustrations or tables. The index is much more detailed than the table of contents.[53]

A table of contents is essential to all but very short reports; however, an index should be used only if the report is long and complicated and the various items are mentioned in several places so that the reader will have to skip about through the report to get the full story on a particular item.[54]

When there are ten or more illustrations, it is helpful to the reader to include a separate list of illustrations. 55 This list should identify each illustration and give the number of the page on which it appears. A long list of illustrations should be a separate part of the front matter. 56 If the list is short, however, it may be run at the end of the table of contents. 57

Although laymen tend to regard abstract and summary as different names for the same piece of writing, discriminating writers and readers recognize a distinct difference between the two. 58 The abstract has certain physical limitations and should be kept quite short since it is used on library catalog cards. 59 The summary, on the other hand, does not have this limitation. The basic distinction, however, is one of function. 60 An abstract discusses the report--it gives a quick answer to: "What is the report about?" 61 The summary digests the report and answers the question: "What did the report say?" 62

An abstract is handled as part of the preliminary matter and it serves the reader who wants to know coverage of the report. 63 The points of real importance to the reader should be included and should be stated concisely and clearly; all other material should be excluded. Neither tables nor illustrations are appropriate in an abstract. 64

A summary may be located at the end of the report as the closing section or it may be placed either at the very

beginning of the report proper or just after the opening section, depending upon the audience and the purpose of the report. [65] It serves the reader who wants to know the substance of the report. It includes information on the manner in which the work was done, the equipment and procedures which were used, a brief discussion of the results, and the major conclusions and recommendations. A summary may include an illustration or a table if it is an aid in covering the subject as briefly as possible. [66]

Both an abstract and summary may be contained in the same report, and usually are. It is quite acceptable to cover the same points in both parts. [67]

The first part of the report proper is usually the introduction, sometimes also descriptively referred to as "Background" or "Nature of the Problem." [68] The purpose of the introduction is to present the subject of the report initially to the reader. Note that it does not present the report itself--that was the role of the preface. A good introduction can kindle a reader's interest in the subject and make him want to get on into the rest of the report. [69]

There is no set formula for writing an introduction because each subject requires individual treatment. Although a certain amount of overlap is inevitable, the introduction should avoid invading the territory of the abstract or summary. [70]

The next sections which are usually encountered in the technical report are those on equipment and procedure. [71] Equipment and procedure should be described in detail when: knowledge of them is needed for an understanding of the results, [72] they are novel, [73] they limit the area in which the conclusions are valid, [74] or they are of possible future use. These sections should give enough information to permit the results to be reproduced at a later date. [75]

A clear, concise description of all important equipment should be given. Clearly labelled drawings are particularly useful in many instances. [76]

It is advantageous to record the procedure in numbered steps. This may simplify later references to specific steps. [77]

Some authors prefer to move the details of the equipment and procedures to an appendix, presenting only a brief summary of these in the body of the report. [78]

The real heart of the technical report is that portion which encompasses the results, discussion, conclusions, and recommendations. [79] The relationship between these parts is sometimes confusing to the novice report writer and many authors make the mistake of lumping them together in one hopeless tangle of fact and conjecture. [80] If these four sections are included in a report, they should be separate and distinct parts with each clearly labeled. [81]

The results should be simple statements of fact offered in such a way that the reader can know exactly what the

author found out. The important thing to remember here is that the results are facts and there is no place in the results section for conjecture. [82] Results known to be invalidated by experimental or other errors should be discarded; however, results should never be discarded simply because they cannot be explained. [83]

In the discussion section, the author is allowed the opportunity for the first time to express his ideas of the mechanisms governing his investigation, of interpreting the results of his experiments and, in general, of offering his personal opinions and views. The expenditure of considerable effort and time on this section is usually warranted. [84] Here it is important to say all that is necessary and to say it in sufficient length to develop smoothly and logically the points involved. It is often better to add a few explanations, even at the risk of appearing verbose, than to be too terse and leave the reader mystified. [85]

Next to wanting to know the results of the work performed, the report reader wants to know their significance. He should not be required to draw conclusions based on his own analysis of the data; [86] the report should do this for him in the section entitled conclusions.

The conclusions should be kept straightforward and as brief as possible and should be stated in decreasing order of importance. Many readers do not have time to read the entire report and they do not want the conclusions hidden or

confused by qualifying opinions and discussions. If they question any of the author's conclusions or are curious to know what they are based upon, they can look back to the discussion section of the report. [87] Unsupported conclusions are inadmissible. [88]

After studying the conclusions, the reader will next want to know what should be done as a result of the investigation. [89] The author should, therefore, propose, in the recommendations section, whatever future action is suitable. Recommendations, like conclusions, should be listed in decreasing order of importance. [90] Recommendations must be supported by conclusions. It is illogical to recommend something when the conclusions have shown that it has no merit. [91]

A simple formula should help to point out the uniqueness of each of these four parts while, at the same time, describing its relationship to the other parts. [92] The facts which evolve from the investigation itself are listed in the results. [93] Added to the results is some logic which is presented and supported in the discussion. [94] This combination yields the conclusions which are "reasoned judgments;" [95] now add a little desire for action to the conclusions and we arrive at the recommendations which are "calls for action." [96]

Let us now turn our attention to the group of sections we have labeled supplementary matter. [97]

The principal function of the appendices is presentation of material pertinent to a complete understanding of the subject which is not part of the main chain of reasoning

in the body of the report. [98] While great masses of detailed test results, for example, may be necessary to confirm the results, they tend to confuse the presentation when given in the normal evolution of the report and should be placed in an appendix. [99] Suitable material for appendices includes charts, tables, illustrations, sample documents, and lengthy mathematical derivations. [100]

The glossary is a brief dictionary of special terms used in the report. [101] It should give a clear and concise definition of each such item and, where necessary, an example of its use. Glossary entries are arranged alphabetically. [102]

A reference list and bibliography both supply information necessary for a reader to locate certain publications that the author thinks might interest him. [103] The difference is that the reference list includes only those publications that are referred to in the report while the bibliography includes publications which the author feels would be of interest to the readers whether or not they were referred to in the report. [104]

Entries in the reference list appear in the order in which they are mentioned in the text and are usually preceded by a number. [105]

Entries in the bibliography, however, are arranged in alphabetical order, usually by last name of senior author, and are not numbered. [106]

Abstract cards are printed on card stock or other heavy paper and, when bound into reports, provide useful tools

107 for the individual report user as well as librarians. These cards are designed to fit into three-by-five-inch card files and can be four to a page. 108 In general, an abstract card should contain all of the bibliographic information needed for quick and easy retrieval of the document to which it refers. 109 It should also contain an adequate abstract of the information contained in the report so that the potential user can determine whether or not he wants the report. 110

The primary recipient of a report must be informed of who, besides himself, has received a copy of the report. For this purpose all recipients are identified in a distribution list. 111 The name of each recipient is given, along with his title, agency name, location, number of copies and copy number of each report sent to him if required. 112

This completes our discussion of the parts which make up the formal technical report. Now if only an informal report were required, which sections could we omit? Of course, for any report we should start with the entire list and omit those parts which we do not need. 113

130 Remember that each report is different and may require different parts. Therefore, for each report, a selection procedure similar to the preceding should be utilized to determine the parts which should be included in that report. 131

SLIDE LIST

1. OPAQUE
2. TARGET SLIDE
3. OBSERVATION BY AN M. I. T. STUDENT
4. QUOTE BY NICHOLAS VANSERG
5. AIRCRAFT TAXIING TO CATAPULT
6. AIRÇRAFT AT FULL POWER ON CATAPULT
7. AIRCRAFT PASSING OVER BOW
8. "THE DEPARTMENT OF AERONAUTICS PRESENTS"
9. "TECHNICAL REPORT WRITING"
10. CARTOON REPORT WRITER IS INTRODUCED
11. CARTOON REPORT WRITER WITH TECHNICAL REPORT
12. SCALES BALANCING EFFECTIVENESS OF DISCLOSURE AND RELIABILITY OF DATA
13. IRATE REPORT READER
14. CARTOON REPORT WRITER
15. "OVERVIEW, PLANNING, PARTS"
16. CARTOON REPORT WRITER BEING REQUESTED TO DO A REPORT
17. CARTOON REPORT WRITER DECIDING PURPOSE OF REPORT
18. CARTOON REPORT WRITER CONSIDERING PARTS OF REPORT
19. TECHNICAL COLLEAGUE
20. TECHNICAL COLLEAGUE, SPECIALIST IN RELATED FIELD
21. TECHNICAL COLLEAGUE, SPECIALIST IN RELATED FIELD, MANAGEMENT
22. TECHNICAL COLLEAGUE, SPECIALIST IN RELATED FIELD, MANAGEMENT, LAYMAN
23. SHORT PASSAGE FROM A REPORT

24. USES, BASIS FOR MORE DETAILED INVESTIGATION
25. SAME AS ABOVE WITH INTRODUCE DISCOVERY ADDED
26. SAME AS ABOVE WITH STIMULATE INTEREST ADDED
27. CARTOON REPORT WRITER WITH MINIMUM TIME AND MATERIALS
28. LIST OF PARTS
29. SAMPLE PAGE OF SHORT REPORT
30. CARTOON REPORT WRITER CONSIDERING PARTS OF REPORT
31. LIST OF PARTS IN FORMAL REPORT
32. LIST OF PARTS IN INFORMAL REPORT
33. SAME AS SLIDE 31 WITH SOME PARTS CROSSED OUT
34. SAME AS SLIDE 28 WITH THREE GROUPS SHOWN
35. SAMPLE PAGES OF FRONT MATTER
36. SAMPLE PAGES OF REPORT PROPER
37. SAMPLE PAGES OF SUPPLEMENTARY MATTER
38. LIST OF PARTS WITH TITLE PAGE HIGHLIGHTED
39. CARTOON CHARACTER DESCRIBING TITLE
40. EXAMPLE OF SHORT TITLE
41. EXAMPLE OF LONG TITLE
42. SAMPLE TITLE PAGE
43. LIST OF PARTS WITH LETTER OF TRANSMITTAL HIGHLIGHTED
44. SAMPLE LETTER OF TRANSMITTAL
45. LIST OF PARTS WITH FOREWORD AND PREFACE HIGHLIGHTED
46. CARTOON REPORT WRITER DESCRIBING DIFFERENCE
47. SAMPLE PREFACE
48. SAMPLE FOREWORD
49. CARTOON DEPICTING FOREWORD AND PREFACE DISCARDED

75. SAMPLE EQUIPMENT SECTION

76. SAMPLE PROCEDURE SECTION

77. SAMPLE COMBINED EQUIPMENT AND PROCEDURE SECTION

78. LIST OF PARTS HIGHLIGHTING RESULTS, DISCUSSION, CONCLUSIONS, RECOMMENDATIONS

79. BEWILDERED READER LOOKING AT HOPELESS TANGLE OF PARTS

80. SAMPLE OF THE ABOVE PARTS IN A REPORT

81. SAMPLE RESULTS SECTION

82. SKETCH OF INVALIDATED AND UNEXPLAINED RESULTS

83. SAMPLE DISCUSSION SECTION

84. CARTOON REPORT WRITER EXPLAINING DISCUSSION SECTION

85. CARTOON REPORT WRITER EXPLAINING CONCLUSIONS SECTION

86. SAMPLE CONCLUSIONS SECTION

87. SKETCH OF UNSUPPORTED CONCLUSIONS BEING DISCARDED

88. CARTOON REPORT WRITER EXPLAINING RECOMMENDATIONS SECTION

89. SAMPLE RECOMMENDATIONS SECTION

90. SKETCH OF UNSUPPORTED RECOMMENDATIONS BEING DISCARDED

91. "HELPFUL FORMULA"

92. SAME AS SLIDE 91 WITH "RESULTS (FACTS)" ADDED

93. SAME AS SLIDE 92 WITH "+ DISCUSSION (LOGIC)" ADDED

94. SAME AS SLIDE 93 WITH "= CONCLUSIONS (REASONED JUDGMENTS)" ADDED

95. "CONCLUSIONS (REASONED JUDGMENTS) + DESIRE FOR ACTION = RECOMMENDATIONS (CALLS TO ACTION)"

96. LIST OF PARTS WITH APPENDICES HIGHLIGHTED

97. CARTOON REPORT WRITER EXPLAINING APPENDICES

98. SAMPLE APPENDIX

99. PAGES OF SEVERAL DIFFERENT APPENDICES

100. LIST OF PARTS HIGHLIGHTING GLOSSARY

101. SAMPLE GLOSSARY

102. LIST OF PARTS HIGHLIGHTING REFERENCE LIST AND BIBLIOGRAPHY

103. CARTOON REPORT WRITER EXPLAINING REFERENCE LIST AND BIBLIOGRAPHY

104. SAMPLE LIST OF REFERENCES

105. SAMPLE BIBLIOGRAPHY

106. LIST OF PARTS HIGHLIGHTING ABSTRACT CARDS

107. SAMPLE ABSTRACT CARD PAGE

108. SAMPLE ABSTRACT CARD WITH BIBLIOGRAPHIC INFORMATION

109. SAME AS SLIDE 108 WITH ABSTRACT ADDED

110. LIST OF PARTS HIGHLIGHTING DISTRIBUTION LIST

111. SAMPLE DISTRIBUTION LIST

112. CARTOON REPORT WRITER RECEIVING REQUEST FOR AN INFORMAL REPORT

113. CARTOON REPORT WRITER WITH LIST OF PARTS

114. CARTOON REPORT WRITER SUMMARIZING TITLE PAGE

115. CARTOON REPORT WRITER SUMMARIZING LETTER OF TRANSMITTAL

116. CARTOON REPORT WRITER SUMMARIZING PREFACE

117. CARTOON REPORT WRITER SUMMARIZING FOREWORD

118. CARTOON REPORT WRITER SUMMARIZING TABLE OF CONTENTS

119. CARTOON REPORT WRITER SUMMARIZING LIST OF ILLUSTRATIONS

120. CARTOON REPORT WRITER SUMMARIZING ABSTRACT AND SUMMARY

121. CARTOON REPORT WRITER SUMMARIZING INTRODUCTION

122. CARTOON REPORT WRITER SUMMARIZING EQUIPMENT AND PROCEDURE

123. CARTOON REPORT WRITER SUMMARIZING RESULTS, DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

124. CARTOON REPORT WRITER SUMMARIZING APPENDICES

125. CARTOON REPORT WRITER SUMMARIZING BIBILOGRAPHY AND LIST OF REFERENCES

126. CARTOON REPORT WRITER SUMMARIZING INDEX

127. CARTOON REPORT WRITER SUMMARIZING ABSTRACT CARDS

128. CARTOON REPORT WRITER SUMMARIZING DISTRIBUTION LIST

129. CARTOON REPORT WRITER WITH REMAINING PARTS

130. LIST OF PARTS AND SEVERAL TYPES OF REPORTS

131. AIRCRAFT IN GROOVE

132. AIRCRAFT PASSING OVER ROUNDDOWN

133. AIRCRAFT IN ARRESTING GEAR

134. "A PALKA-ZORRO ENTERPRISE"

135. "PRODUCED BY THE EDUCATIONAL MEDIA DEPARTMENT"

136. NAVAL POSTGRADUATE SCHOOL SEAL

BIBLIOGRAPHY

AUDIO-VISUAL PROCEDURES: The following list includes some of the publications of interest to those planning a tape-slide lecture.

Advanced Camera Techniques for 126 and 35 mm Cameras, Kodak Pamphlet No. AC-56, Eastman Kodak Company, 1970.

Audiovisual Planning Equipment, Kodak Pamphlet No. S-11, Eastman Kodak Company, 1971.

Close-up Pictures with 35 mm Cameras, Kodak Pamphlet No. AB-10, Eastman Kodak Company, 1971.

Effective Lecture Slides, Kodak Pamphlet No. S-22, Eastman Kodak Company, 1971.

New Adventures in Indoor Color Slides, Kodak Pamphlet No. AE-7, Eastman Kodak Company, 1969.

Nine Steps to Fame and Glory, Minnesota Mining and Manufacturing Company, 1971.

Planning and Producing Visual Aids, Kodak Pamphlet No. S-13, Eastman Kodak Company, 1971.

Planning a Photo Easay, Kodak Pamphlet No. AT-39, Eastman Kodak Company, 1967.

The Here's How Book of Photography, Kodak Pamphlet No. AE-100, Eastman Kodak Company, 1971.

TECHNICAL REPORT WRITING: The following list includes some of the publications available to technical report writers.

Kirkpatrick, T. W. and M. H. Breese, Better English for Technical Authors, The MacMillan Company, 1961.

Rathbone, R. R., Communicating Technical Information, Addison-Wesley, 1966.

Rhodes, F. H., Technical Report Writing, McGraw-Hill, 1961.

Turner, R. P., Technical Report Writing, Holt, Rinehart, and Winston, 1965.

Van Hagan, C. E., Report Writers' Handbook, Prentice-Hall, 1961.

Weil, B. H., The Technical Report, Reinhold Publishing Corporation, 1954.

WIND TUNNELS: The following list includes some of the publications available on low-speed wind tunnels.

Gorlin, S. M. and I. I. Slezinger, Wind Tunnels and Their Instrumentation, Israel Program for Scientific Translations, Jerusalem, 1966.

Pope, Alan and J. J. Harper, Low-Speed Wind Tunnel Testing, John Wiley & Sons, 1966.

Pankhurst, R. C. and D. W. Holder, Wind Tunnel Technique, Pitman Publishing Corporation, 1952.

Robinson, R. F. and D. H. Novak, Introduction to Wind Tunnel Testing, Shaw's Letter Shop, 1952.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Documentation Center Cameron Station Alexandria, Virginia 22314	2
2.	Library, Code 0212 Naval Postgraduate School Monterey, California 93940	2
3.	Chairman Department of Aeronautics Naval Postgraduate School Monterey, California 93940	1
4.	Assoc. Professor R. D. Zucker, Code 57 Zu Department of Aeronautics Naval Postgraduate School Monterey, California 93940	1
5.	Assoc. Professor Ulrich Haupt, Code 57 Hp Department of Aeronautics Naval Postgraudate School Monterey, California 93940	1
6.	Major Fred Palka, USMC 22317 Capote Drive Salinas, California 93901	1

ICLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

INATING ACTIVITY (Corporate author) /al Postgraduate School nterey, California 93940	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

ORT TITLE

pe-Slide Lecture Packages for Use in Aero Laboratories

CRIPTIVE NOTES (Type of report and, inclusive dates)

ster's Thesis, March 1973

HOR(S) (First name, middle initial, last name)

ed Palka

ORT DATE rch 1973	7a. TOTAL NO. OF PAGES 75	7b. NO. OF REFS 18
NTRACT OR GRANT NO. OJECT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

STRIBUTION STATEMENT

proved for public release; distribution unlimited

PPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Naval Postgraduate School Monterey, California 93940

BSTRACT

Overcrowded conditions, unavoidable absence, and course priority ı aero laboratories led to a quest for an instructional method which ɔuld alleviate these problems without increasing the instructional ɔrkload. The tape-slide lecture apparatus was selected as the ehicle for conveying the necessary information. Detailed scripts ere written, slides were prepared and fully automatic and synchro- ized audio-visual packages were assembled. The results are four ndividual packages: The Low-Speed Wind Tunnel--Introduction, he Aerolab Low-Speed Wind Tunnel--Description, The Aerolab Low-Speed ind Tunnel--Operation, and Technical Report Writing. Reaction to he results was favorable. It was concluded that the method was ffective and recommended that work in this field continue.

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Audio-Visual						
Education						
Laboratory Experimentation						
Lecture Package						
Report Writing						
Tape-Slide						
Wind Tunnel						

Thesis 143991
P1434 Palka
c.1 Tape-slide lecture packages for use in aero laboratories.